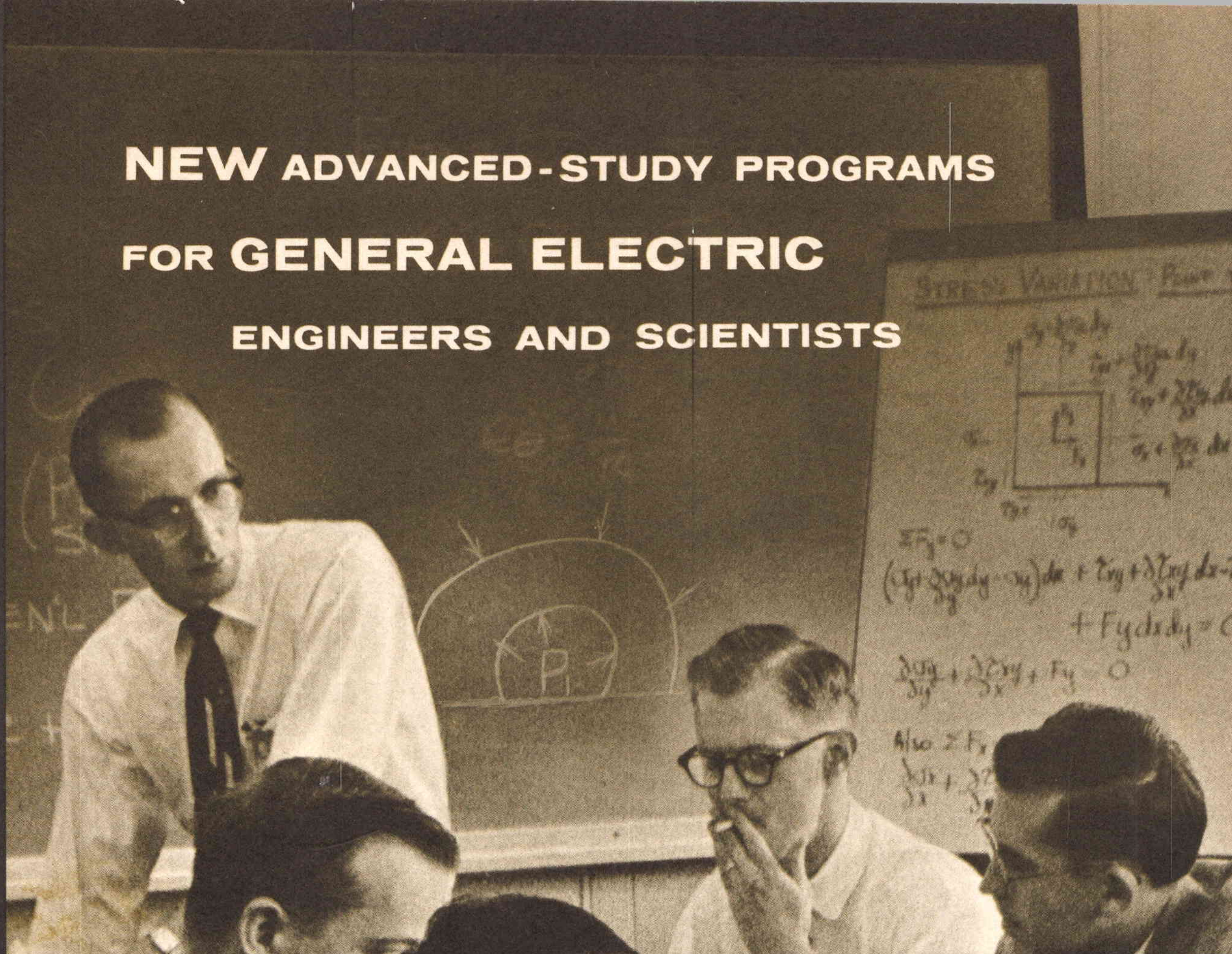
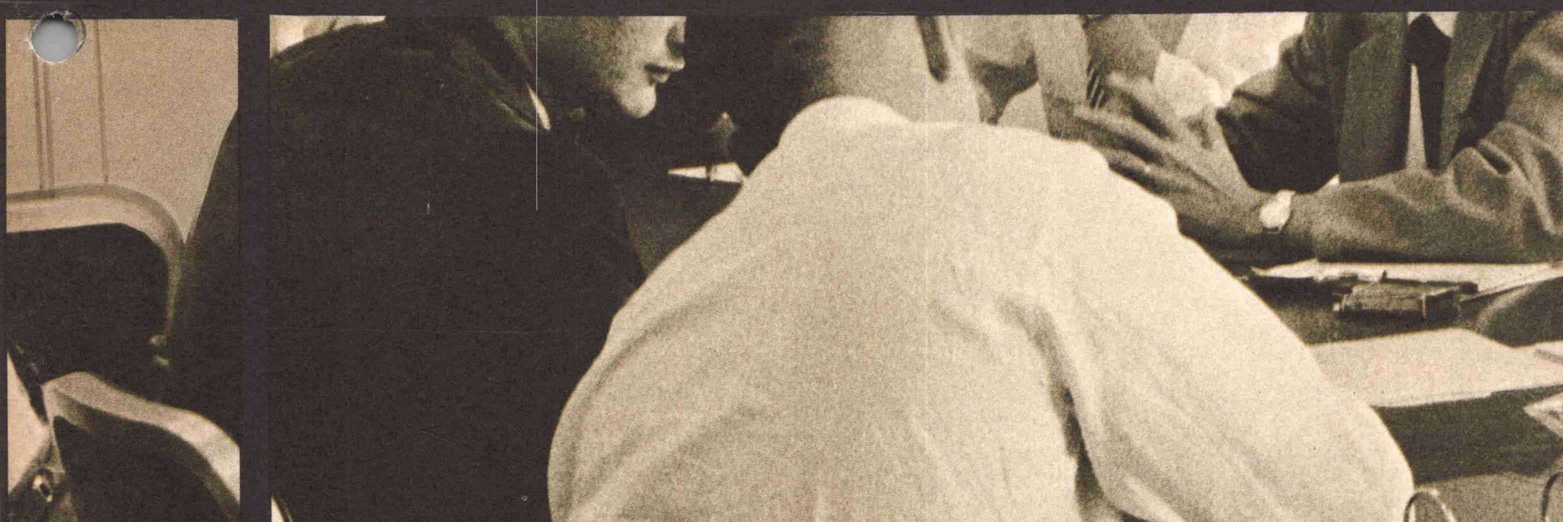
NEW ADVANCED-STUDY PROGRAMS FOR GENERAL ELECTRIC ENGINEERS AND SCIENTISTS

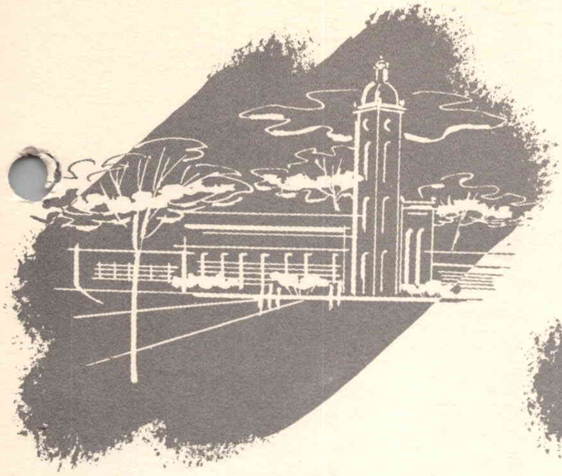
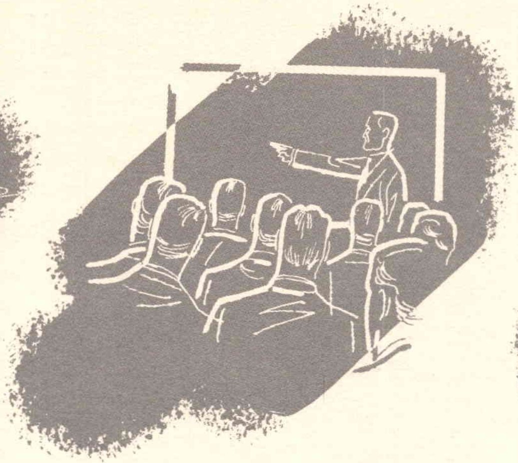
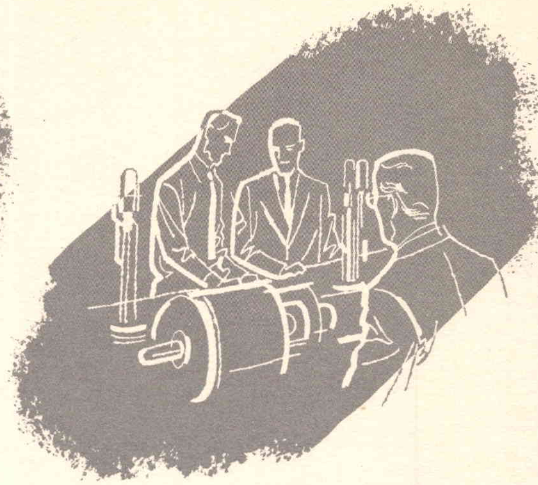






New programs combine professional on-the-job training with either university study or G-E graduate-level courses



WHAT THESE PROGRAMS MEAN TO YOU

In meeting today's industrial problems and challenges, the graduate engineer or scientist is continually seeking to improve his own technical competence. He finds that to meet his goals and to prepare himself for the job of tomorrow, he must perfect his abilities and skills and remain abreast of the newest developments in his fields. These are the main considerations and philosophy of General Electric's new Advanced-Study Programs.

Extension of your formal education

You will have the opportunity, as a General Electric employee, to continue your formal education at one of several leading graduate schools. Depending on your objectives and specialty, you may either take selected graduate courses or you may participate in the G-E Honors Program for Graduate Study, which will lead to your Masters Degree or, if qualified, eventually to your Doctorate Degree. The expenses of fees and books are paid by General Electric.

Opportunity to study under industry's leading engineers and scientists

In addition to university study, General Electric offers a series of graduate-level company programs; instructors are men who have gained wide recognition as authorities in their particular fields. The courses have proven their merit in the professional achievement and distinction attained by the graduates. Most of the course graduates become engineering specialists and professional managers.

Opportunity to apply your knowledge to the current problems of industry and science

These programs offer you unparalleled opportunity for achieving proficiency in solving the challenging engineering problems which face our rapidly expanding technology. "On-the-job" training is not an empty cliché at G. E. Men on training assignments are rotated through a series of responsible positions in an integrated program of study and work. You will quickly find responsibility and challenge in the work of your choice.

THE OPPORTUNITY IS YOURS

When you graduate from college, you might possibly feel that your education is behind you. Actually, a new phase of your education is just beginning — an education which will help you grow to fill an engineering position of responsibility and stature.

Now is the time to plan carefully for your future and to establish a solid engineering foundation upon which to advance. This responsibility is yours. The Company cannot develop men: men develop themselves. The Company will give you help, guidance and opportunity, but you must take it upon yourself to utilize these services. You will find that they are yours for the asking.

YOUR INTERESTS

Every engineer or scientist who comes with the Company is an individual and will look at the future as it pertains to his own interests, abilities, ambitions and needs. It was for this very reason that the Engineering and Science Programs were developed and course work instituted to support the rotating assignments. One of the Company's strongest points is the broad opportunity offered to young engineers and scientists and the wide latitude offered each man for his own self-development.

The Engineering and Science Programs answer different questions for different people. Perhaps you may know exactly what kind of work you would like to do but have no idea as to how best to prepare for this type of work. Perhaps you may be undecided as to your future career and would like to plan a varied program to determine your career direction; or you may have a definite interest in a specific field of science but may not know how best to increase your technical competence in this field. Whatever your objective, it is important that you think over carefully what you would like to do in the first year and begin crystallizing your thinking and establishing your goals.

Today's young engineer and scientist finds two paths along which his career may proceed: he may follow a career of management, where his efforts will be primarily the direction of a business activity; or he may wish to continue his close alliance with technical work where he will eventually be concerned with the technical direction of others.

Regardless of which path a man decides to follow, it is generally wise in the early stages of his career to obtain as much sound and fundamental engineering experience as possible.

If an engineer is to become a good manager, he must have an understanding of technical problems. If he is to become an individual contributor, intensive technical experience will provide him with a store house of knowledge which can be relied upon in complex problem situations. Therefore, the young engineer would be wise to plan his early experience and education along the path which interests him most from a technical standpoint and which will provide him with a good engineering background.

THE FIRST YEAR

Within General Electric it is possible to find almost any type of engineering work in which you may be interested, since the company manufactures a great variety of products ranging from steam turbines to transistors and exposure meters. This tremendous diversity allows you to select a job which will be patterned to suit your particular capabilities and interest. Because of this spread in job opportunities it is even more important that you find out what type of work you are best suited for and plan a program of study that will prepare you for this work.

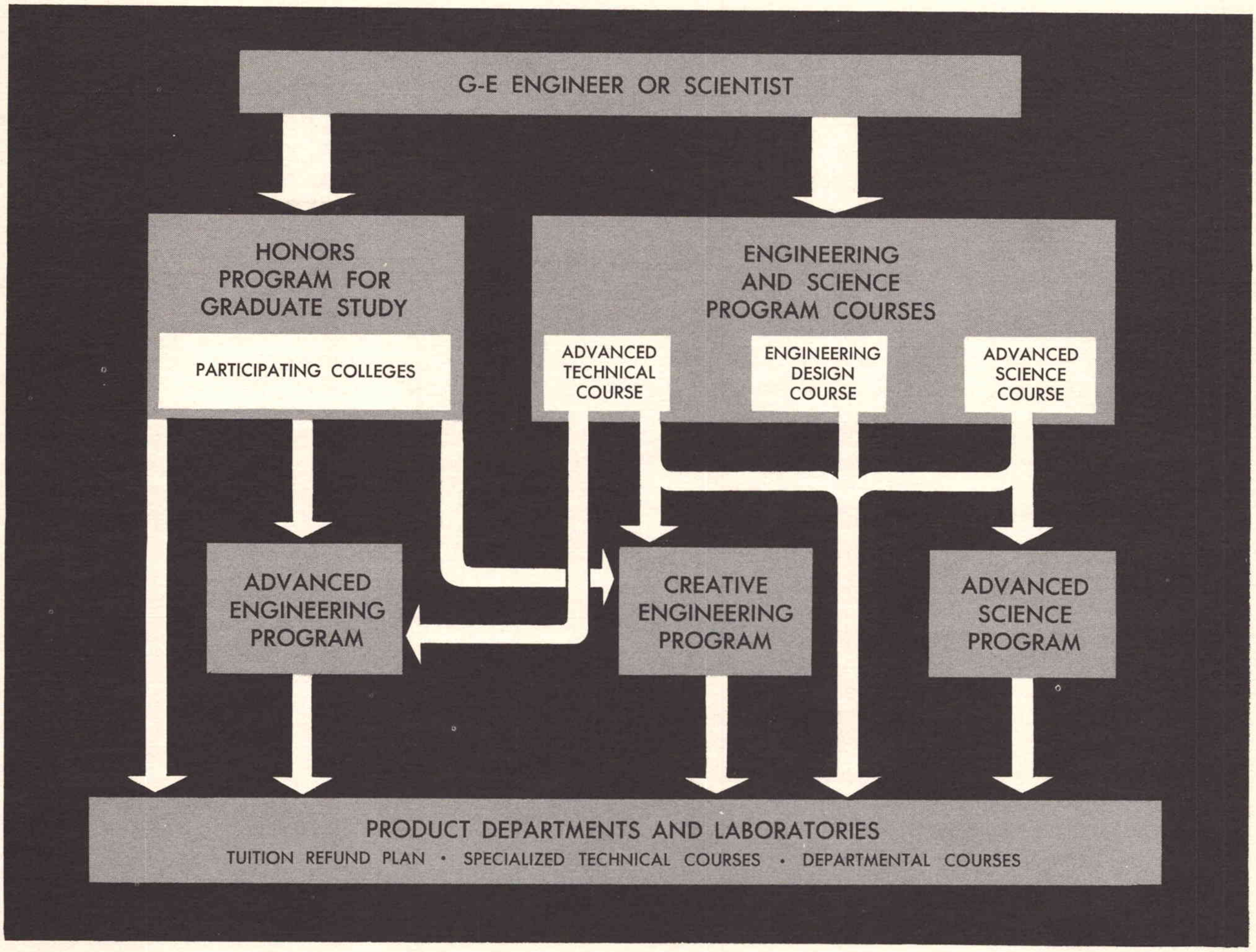
Engineering work may be considered to be divided into three fields, and certain courses are more valuable in one field than in another. These fields and the associated courses are as follows:

1. Advance Engineering - The Advance Engineer's basic responsibility is to create new fundamental concepts, which will eventually be utilized in a product, and to conduct investigations and studies of theories that might develop into these concepts.

This field is generally known as development engineering outside the Company. A thorough understanding of engineering fundamentals is required to perform this work and the Advanced Technical Course has been developed to prepare men for this type of work. This course leads to the Advanced and Creative Engineering Programs, depending upon whether a man is interested in the more creative or more analytical type of advance engineering

For the Chemist, Metallurgist, or Chemical Engineer, the Advanced Science Course provides the background for Advance Engineering in the field of materials or processes. For the Physicist, either the Advanced Technical or Advanced Science Course may be helpful. The Advanced Science Course leads to graduate study on the Advanced Science Program.

2. Design Engineering - The Design Engineer is concerned with the conceptual visualization and application of ideas that have been proven feasible by Advance Engineers. These ideas are usually not practical, repeatable, or economic in the form submitted by the Advance Engineer. The Design Engineer takes the basic idea and shapes it into a workable system or component which is then capable of being manufactured. The Engineering Design Course is directed at this type of individual and teaches the application of the fundamentals learned in college in the practical creation of a new product or device.



3. Production Engineering - When a design has been established, it must be placed into production and carefully processed to insure that the basic design concepts are maintained through the manufacturing process. The Production Engineer is responsible for this follow-through and improvement of the device as it is manufactured. He often is required to change the design or alter the manufacturing process to insure adequate functional working of the product. He must have a great deal of practical knowledge in both the engineering and manufacturing areas. The Engineering Design Course is beneficial to the man interested in this type of work, since it gives him a broad background in engineering and product understanding.

GRADUATE STUDY

Depending on your personal needs, you may continue your formal education on the Tuition Refund Plan or the Honors Program, both leading to Master's Degrees. The Tuition Refund Plan pays the expenses of tuition, fees and books at an accredited college and allows up to four hours off per week for attendance of these classes. The Honors Program allows you to complete your requirements for a Master's Degree in 1 1/2 years while working half-time on industrial work.

SPECIALIZED TECHNICAL COURSES

Since an engineer's education never ceases, the Company has developed courses that you may take when you become permanently assigned to an operating department regardless of the locality. These are Specialized Technical Courses and are courses of interest in all fields of technology. When you are permanently established, you will have a much better understanding of the specialty in which you intend to develop, and at that time you will be able to enroll in these courses to increase your specialized knowledge.

ADDITIONAL INFORMATION

All General Electric engineering and science personnel have the opportunity to participate in the Advanced-Study Programs. The flow chart, shown above, illustrates the many paths available for continuing your education and professional training.

Detailed information on each of these courses and programs is included on the following pages.

SUMMARY OF GENERAL ELECTRIC'S ADVANCED-STUDY PROGRAMS AVAILABLE TO YOU

ADVANCED TECHNICAL COURSE

The Advanced Technical Course is General Electric's basic educational opportunity for engineering and scientific graduates interested in the more highly technical aspects of design and advance engineering.

OBJECTIVES

This course is designed to provide the situation and the atmosphere necessary for each individual to build an understanding of basic engineering fundamentals through application to realistic problems.

The Advanced Technical Course is organized to aid the college graduate in:

1. Developing an understanding of the fundamentals of engineering analysis;
2. Recognizing the usefulness of uncovering his potential creative ability;
3. Promoting a balance between creative and analytical techniques;
4. Organizing his thinking and establishing an approach that will aid him in the solving of engineering problems;
5. Building his engineering self-confidence;
6. Formulating his goals and objectives through self-evaluation.

CONTENT

To accomplish the development of a sound technical understanding in such typical fields as dynamics, vibrations, electricity and magnetism, fluid mechanics, heat transfer, and elasticity, graduate level technical material is presented. The emphasis is on understanding the physical picture involved, their practical aspects, and order of magnitude. In order to achieve this understanding, it is necessary to introduce or reacquaint the class members with the mathematics of differential equations, partial differential equations, vector analysis, and complex variable notation. Interrelationship of the fields of study and their associated mathematics are investigated in order to produce an integrated knowledge. Lectures are given by authorities in the area under study.

Subjects Covered

Dynamics & Vibrations
- Fundamental Dynamics Concepts
- Vibrations - Single & Multiple Degree
- Particle & Rigid Body Dynamics

Electricity and Magnetism
- Basic Field Concepts
- Static and Time Varying Fields
- Maxwell's Equations
- Energy and Forces in Fields

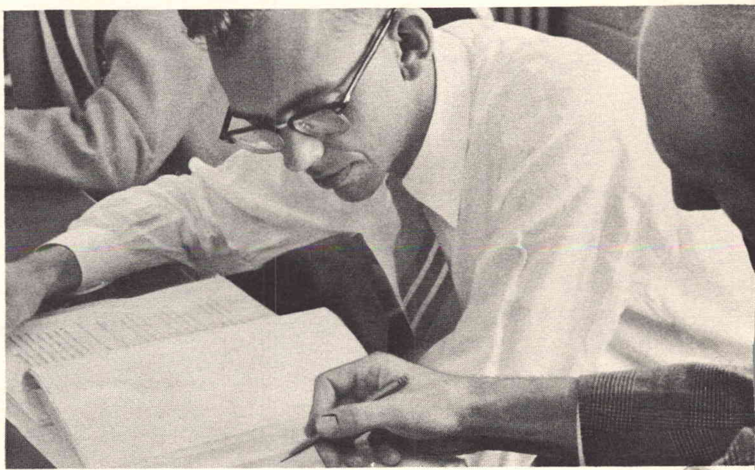
Fluid Flow
- General Equations of Fluid Flow
- Potential Flow
- Viscous Flow
- Boundary Layer Theory
- Compressible Flow
- Thermodynamics

Heat Transfer
- Conduction, Convection, Radiation
- Equivalent Circuits, Flux Plotting

Elasticity
- Plane Stress, Plane Strain
- Stress Functions
- Static Energy Methods
- Dynamic Energy Methods

Systems
- Block Diagrams, Transfer Functions
- Bode Analysis
- Stabilization Networks

Probability & Statistics
- Basic Probability
- Math Probability
- Statistical Inference
- T & F Tests



Advanced Technical Course provides ample text material for home study and for future reference when on the job.

Nuclear Physics
Atomic Structure; Radioactive Decay; Nuclear Fission

Mathematics
Differential Equations, Total and Partial; Vector Algebra; Vector Calculus

Presentation
Oral; Written; Visual

THE ENGINEERING METHOD

In order to effectively assist the class member in applying the basic engineering concepts such as Newton's Laws and Maxwell's equations, emphasis is placed on an understanding of the chronological procedure used in actual problem solving situations. The men are then encouraged to use the structural elements of this procedure in their actual work assignments.

Some of these elements are: the importance of carefully establishing assumptions, a knowledge of limiting conditions, understanding the problem objectives, hypothesizing the conclusions to be expected, and the necessity for interpreting the actual and practical meaning of a theoretical answer. The ability to quickly and rapidly make use of this procedure will greatly assist the class member in organizing his thinking to achieve optimum engineering solutions.

TEXT MATERIAL

Each class member is given:

1. "Fundamentals of Engineering Analysis" - written especially for this course by the Engineering Education staff.

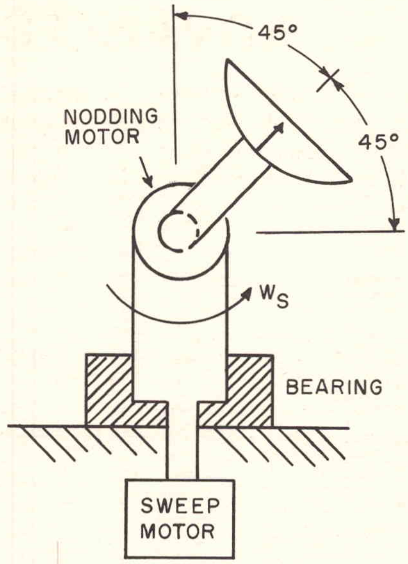
2. "The Elements of Probability Theory and Some of Its Applications" by Harold Cramer, J. Wiley and Sons, Publisher.

HOMEWORK AND CLASSWORK

Homework consists of reading reference material and or the supplied text, and working the assigned problem for the week. A total of approximately 20-25 hours per week are required. Beginning early in the fall, the course extends for approximately 34 weeks. Class sessions are held for 4 hours per week on company time.

Typical Homework Problems

A variety of problems are offered in the course designed to accomplish different objectives. A typical problem emphasizing engineering fundamentals and advanced mathematics is the investigation of the dynamics of a radar antenna system to determine the dynamic forces and torques involved under operation. The design considered is shown schematically above.



Schematic of Antenna Drive

The antenna is rotated about the vertical axis at a constant speed by the motor shown. The antenna nods sinusoidally at a constant frequency and an amplitude of 45° between the horizontal and vertical planes.

A typical problem requiring an understanding of vector analysis and Maxwell's Equations would be the calculation of the forces, fields, flow velocities, and electric currents existent in an electro-magnetic pump. These pumps have no moving parts and pump liquid metals (sodium, mercury) by the interaction of induced currents in the flowing metal and magnetic fields generated by the pump coils.

All problems are realistic and have arisen in actual engineering departments in recent years. They are illustrative of today's unique and complex technical challenges.

COURSE SUPERVISORS

The class supervisor is a graduate of the Company's Advanced Technical Programs; he has considerable engineering experience and knowledge of the Company and its products. His primary responsibility is the educating, guiding, and counselling of the class members; and he is employed full time in this capacity.

CLASS LOCATIONS

The Course is offered in a synchronized schedule in all the major plant locations of the Company. This permits a class member to transfer from one location to another during the course, thus giving him an opportunity to become acquainted with the various types of work and the various products manufactured. In this manner he is better able to choose the product department where he will later

begin his career, and an opportunity is thus provided for him to apply, on a variety of engineering assignments, the techniques he is learning in the course. Class size is usually limited to about fifteen members. This limitation is necessary if individual counselling and guidance is to take place.

Selected students may also complete the course requirements by correspondence after working for the first three months in a formal class. This gives the class member the opportunity of seeing locations other than those having formal classes.

ATC is also offered by correspondence to members of the Armed Forces who were participating in the course at the time of their induction into the service.

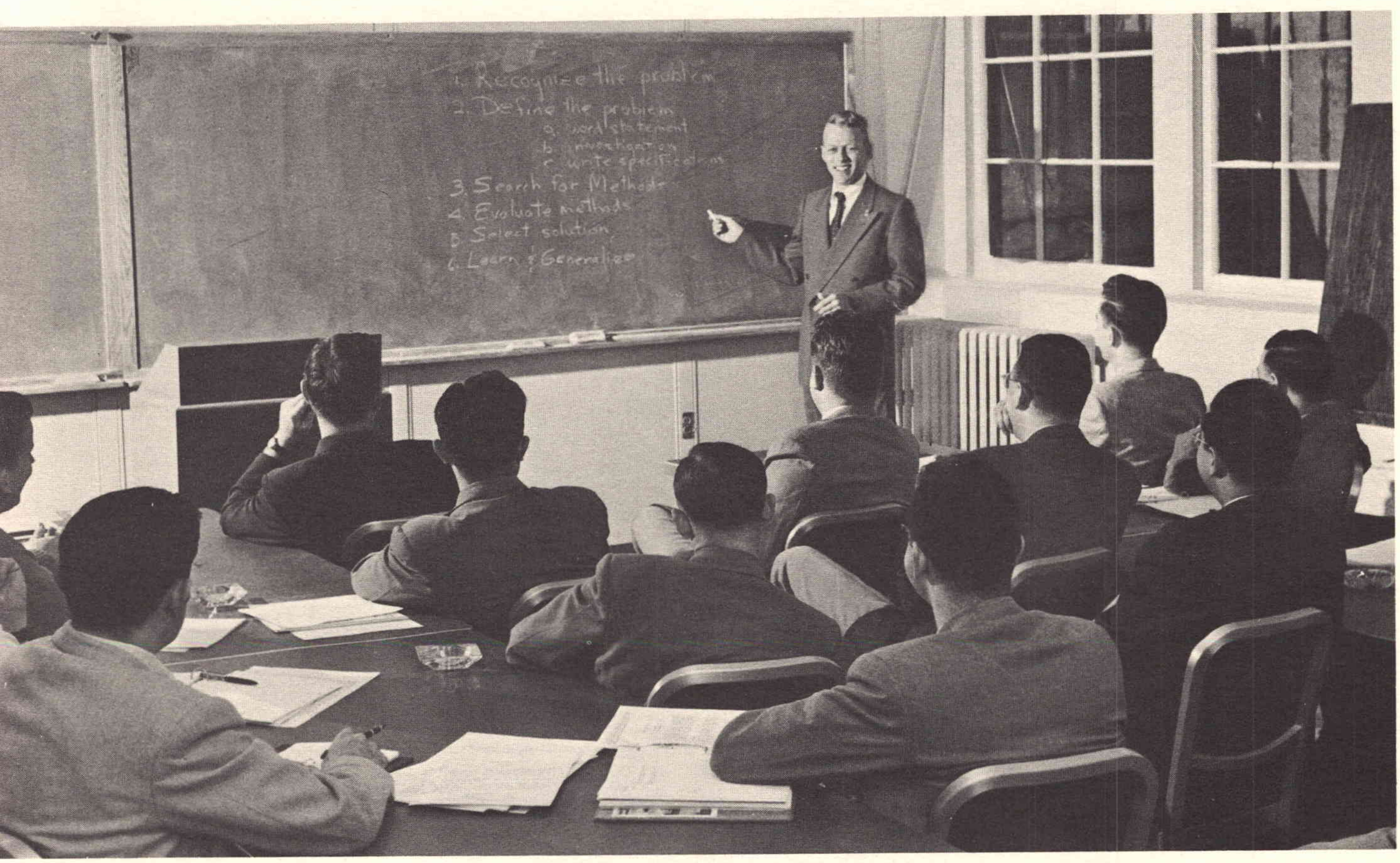
ELIGIBILITY AND SELECTION

Participants in the Advanced Technical Course are selected from among participants on the Engineering and Physics Programs. A few qualified engineers from operating departments are also selected, with the approval of their department managers. Selections are based on interest in and suitability for this type of course and the work that it equips the men to do, plus technical ability, character, personality and initiative. The course is designed primarily for men interested in Advance and Design Engineering work.

It is recommended that all applicants have either an engineering or scientific degree. Selection of individuals to participate in the course will be on the basis of professional qualifications, experience, review of a typical homework assignment which all applicants must complete and submit, and an individual interview with one of the Advance Technical Course Class Supervisors.

PLACEMENT

Most graduates of the Advanced Technical Course will continue their educational training in the Creative or Advanced Engineering Programs. Many choose to assume full-time engineering responsibilities in the operating departments in positions demanding this high-level of training.



Classes in the Advanced Technical Course normally meet for four hours a week during regular working hours.

ADVANCED SCIENCE COURSE

OBJECTIVES

The Advanced Science Course was established to train Metallurgists, Chemists, Chemical Engineers, and Physicists in materials engineering or in process engineering by providing education at a graduate level in fundamentals of engineering, philosophy of problem solving and in materials in the materials option or mass transfer in the processes option.

In the materials option, the training is aimed at rounding out the scientific background by applying it to engineering situations and providing a means of developing an understanding of the other engineers' work and method of operation. The limitations and lack of complete understanding of present materials has made the field of materials engineering very important.

In the process option, the training is aimed at broadening the engineering background as well as the process background. The need for understanding in the field of washing, drying, boiling heat transfer, as well as the classical processes-distillation, absorption, etc., has brought forth this new need for process people throughout the Company.

TEXT MATERIAL

a) Advanced Engineering Program Staff, "Fundamentals of Engineering Analysis", General Electric Co. (1953).

b) Prutton, C. F. and Maron, S. H., "Fundamental Principles of Physical Chemistry", Macmillan Company - New York (1944).

c) Seitz, F., "The Physics of Metals", McGraw Hill, New York (1943).

d) Zwikker, C., "Physical Properties of Solid Materials", Interscience, New York, (1954).

HOMEWORK

Approximately 20-25 hours per week are devoted to homework - including problems, and exercises in problem approach. The course lasts 34 weeks.

Typical Homework Problem

Depth of Carburization

The benefit of a tough low carbon core and a hardenable high carbon surface can be obtained by diffusing carbon into a low carbon steel. This process is known as carburizing and can be carried out in a number of ways. Pack carburizing is accomplished by packing low carbon steel parts in a mixture of charcoal and barium carbonate and heating to a temperature around 1700°F. During the process an excess of carbon is always at the surface of the steel, the diffusion of carbon into the interior being the limiting factor. Since only carbon solid solution can take part in diffusion, the maximum effective carbon concentration at the surface of a steel is determined by the solubility of austenite (the high temperature form of iron) for carbon. At 1700° this value is 1.3 per cent by weight.

Consider the pack carburizing of 18" lengths of 1" round SAE 1010 steel. This is a plain carbon steel containing 0.1 per cent carbon.

1) Plot the carbon penetration curve, carbon content versus distance from the surface of the specimen, that would be produced by carburizing for three hours at 1700°F.

2) Determine the time required to obtain a carbon content of 0.6 percent at a depth of 0.05 inch.

The diffusion constant for carbon in austenite is given with 10 per cent accuracy by the equation,

$$D = (0.07 + 0.06 \times \text{weight per cent C})\, e^{\frac{-32000}{RT}} \quad (\text{cm}^2/\text{sec.})$$

where R is the gas constant, 1.987 cal/°K/gram-mole, and T is the temperature in °K.

It will be necessary to make a number of assumptions in order to obtain a solution to this problem in a reasonable length of time. Discuss the effect of these assumptions on the accuracy of your results.

COURSE SUPERVISOR

The supervisor is a man with a background in chemistry, chemical engineering, metallurgy or physics coupled with two to three years of experience with the General Electric Company. Another requirement is that he be versatile in engineering and scientific fields since both are important areas of the course.

CLASS LOCATION

This class has been given in Schenectady.

The class location is based on the number and quality of assignments available. Class size will be 10-15 men, of which about 60% are metallurgists and physicists, 40% are chemists and chemical engineers.

WORK ASSIGNMENTS

(Especially arranged for participants in this course). Assignments will vary from work in materials and process laboratories and in design of process equipment to research. A typical research assignment is one at the Research Laboratory in Schenectady.

Location: Research Laboratory - Metals and Ceramics Building

General Description of Research Activities: Investigation of basic effects of nature - why things behave as they do, etc. Definite accomplishment or results are expected.

Description of particular assignment: Two areas of responsibility were assigned (1) to investigate the making of nodular iron from flake cast iron by heat treatments rather than by melting. (2) investigate growing single crystals of aluminum by melting without allowing fusion through the oxide skin. Determine effects of crystals orientation.

These assignments are carried through and are the responsibility of the assignee. Naturally, many men at the Laboratory are more than willing to discuss ramifications of these problems.

PLACEMENT

The materials graduates of the ASC may find work in advanced engineering acting as materials engineers. It may then be their responsibility to design for the materials and to set up the manufacturing process and specifications. They may also find work in applied research and development, seeking out new materials or new ways of improving existing materials.

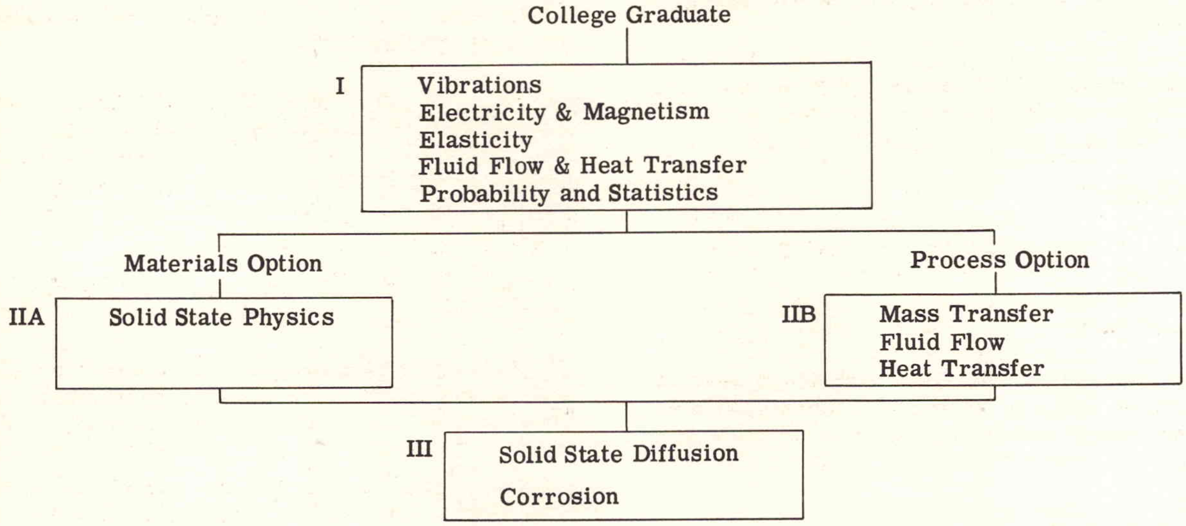
The process graduates may find work in advance engineering, perhaps specializing in heat transfer and fluid flow or working on projects which may generally be described as unit operations and processes. The course broadens the opportunities available to the graduate by developing his talents in a variety of engineering fields.

Interested class members may apply for the Advanced Science Program. Selections to this program are based on interest and aptitude.

ELIGIBILITY AND SELECTION

Men interested in the Advanced Science Course should write to Engineering & Science Program Courses, Building 36, Room 441, Schenectady. Men with background in Chemistry, Chemical Engineering, Metallurgy, and Physics should apply. Applicants will be selected on the basis of an entrance problem and an interview. Applicants should have one year of physical chemistry, or equivalent, one year of college physics and differential and integral calculus. Differential equations, solid state physics, strength of materials, and unit operations are useful but not required.

Course Content



I. This area includes many of the engineering areas of the course. It is not the intent of this area to make experts out of the class members, but rather to provide orientation and train the students to be able to solve the less complicated problems. During these sections, differential equations and vector calculus will be taught.

IIA. This section presents to the materials engineers the basic theory for the behavior of materials. It includes dislocation theory and band theory of solids.

IIB. This section presents to the process engineers the basic theory behind mass transfer coupled with the required theory in heat transfer and fluid flow. For example, boiling heat transfer is covered in this area.

III. This section provides an education in phenomena needed by both types of engineers. The solid state diffusion is concerned mostly with Fick's Laws, the corrosion section with electrochemistry.

ENGINEERING DESIGN COURSE

OBJECTIVES

The objectives of the Engineering Design Course include:

1. Bridging the gap from the theoretical aspects of engineering as they exist on the campus to practical, multiple-answer type industrial problems.

2. Product, Company, and professional orientation.

3. Assistance in the selection of the right kind of job in the right product department.

4. An intensive grounding in problem-solving techniques, creative thinking, and creative engineering techniques.

5. The promotion of the conviction that there is an adequate answer to every engineering design problem and that any astute, alert young engineer is capable of finding it.

6. Development of a professional understanding of and competence with engineering materials and manufacturing processes.

7. Development of professional report writing and oral expression skills.

8. Development of a professional ability to appraise and evaluate a product from the viewpoint of time, money, manpower, appearance, function, value, and cost.

To summarize the objectives in one phrase, it is "to accelerate the experience rate of product design-oriented engineers new to General Electric".

DISCUSSION

There are now over 110 product departments in approximately three dozen distinct geographical locations throughout the country. Each trainee should know as much as possible about these many product departments before he makes his decision to "go permanent" in any one. The Engineering Design Course helps to solve this problem; in each of its 30 weeks, a different product department is studied. Among other things, the following are decussed:

a. A brief history of the department, and its place in the Company organization.

b. The industry of which it is a part, and what its competitive position is today, in the short-term and long-term future.

c. The size and organization of its Engineering Section.

d. An over-all look at its complete line of products and the dollar volume of business of each.

e. An intensive description of the specific product.

f. A case history of an important design problem related to that product, from the conception of the idea to the finished product ready for shipment.

The Engineering Design Course explores in great detail the realtionship between the Advance, Design, and Production Engineer, and how they work together in the many areas of Company activity. Although the major emphasis in the Course is on the Design Engineer, the extent and limitations of advance and production engineering, and their relation to the Design Engineer, are clearly delineated.

Another ingredient that is missing in the young man is "experience", that abstract, almost undefinable quantity that assumes so much importance in almost everything we do. What is experience?

a. It is knowing where, in or outside the Company to go for information. It is knowing names and assigned responsibilities of those around you.

b. It is knowing the abilities, limitations, and assigned responsibilities of those around you.

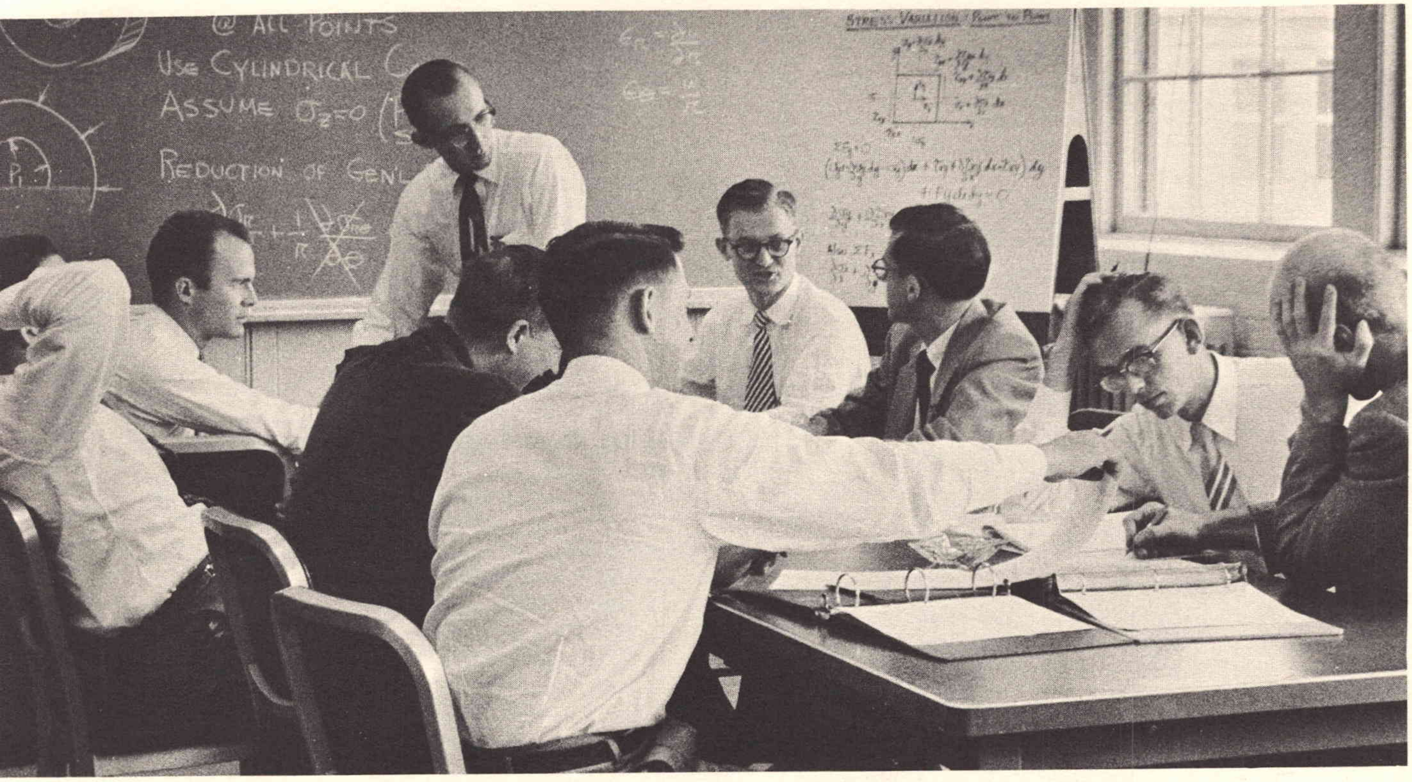
c. It is knowing the relationships between a problem's scope and the time, money, and manpower required to solve it.

d. It is the practiced ability to recognize, define, and solve practical multiple-answer type problems in a systematic, completely functional way, and the ability to subdivide a problem into its many component parts, and to organize the team of specialists required to solve each part.

e. It is the trained "intuition" or "instinct" for knowing what is right and what is not.

f. It is the ability to select the correct material and the manufacturing processes by which the material will be fashioned.

All these, and others, are the experience a new man needs. The Engineering Design Course "accelerates the experience rate "of engineers new to the Company by exploring each of the areas described above. It should be noticed that in the process, no new mathematical relationships are added to those of the four-year curriculum. Rather, the Course convincingly demonstrates how the technological tools of the undergraduate curriculum can be brought to bear to solve practical engineering problems.



Advanced courses and programs on a graduate level provide unlimited opportunity

The Engineering Design Course's first aim is to help locate and equip the new engineer to take his desk, start work, and produce at a uniformly efficient rate.

COURSE CONTENT

The Engineering Design Course is composed of 26 weekly "packages" that are complete within themselves. Each package consists essentially of four parts:

1. A product design study.
2. An assigned problem.
3. Supplementary reading or reference material.
4. A weekly class.

PRODUCT DESIGN STUDY

The product design study relates in detail how experienced engineers overcame a formidable practical problem in product design engineering. It is in effect, the reorganized diary of an engineering group, from the conception of an idea, or the moment of problem recognition, to the successful conclusion of the project from which it grew.

The average product design story is approximately 20 pages in length, and includes about a dozen photographs or drawings. Estimated average study time is 3 - 5 hours.

Each product design story contains all of the following:

1. Background of the operating department

This section of the product design story serves two purposes:

a. It acquaints the Engineering Design Course class member with the department and its products so that they get a "feel" for the story that follows.

b. It introduces the department, in spirit and attitude, to the class members, the majority of whom have never seen the plant, and who most probably until this moment have not considered it as the department in which they hope to locate permanently.

It answers such questions as: What is the department's competitive position in industry? How many engineers are there in the department? What is its annual dollar volume of business? What is the scope of its products, in size, weight, cost, number? Who are its customers?

2. Background of the product

This section of the product design study focuses the class member's attention on a particular product, its history, its functions, its future, of what and how it is made, its "design cycle", etc.

3. Recognition of the need

From the moment that the class member starts to read the product design study, he is prepared to meet a problem. In this section of the product design study, the irritant is recognized, and a hazy outline of a problem begins to form.

4. Problem definition

This is usually the most important section of the product design study. It is here that mature engineering judgment frames the paramaters within which a problem is defined. Answered are such questions as: How long did it take to define the problem? How many people were involved and what was the contribution of each? How much of the definition was the result of marketing predictions, product planning, engineering intuition, development budget limitations, time restrictions, competitive stimulus, computer work, slide rule work, selling price, manufacturing capabilities, materials selection, etc.?

5. Preliminary search for methods

The class member is made to feel a part of the engineering team beating the bushes for a solution. Even the poorly conceived notions that were quickly discarded are mentioned. Also included in this section are the reference works that were used, the mathematical relationships upon which approach was built, any vendors and their contributions, and the laboratory, plant, or service facilities at their disposal.

6. Evaluation of alternate methods

A thorough description of the evaluation process is part of every product design study. Sometimes the first evaluation results in selection and solution, but more often the evaluation process reveals new facets of the problem definition. The problem is then redefined, a new search for methods is then initiated, and a re-evaluation ensues. This cycle is repeated as often as is necessary.

7. Selection of the method.

In many of the product design studies, the main problem is not one concerned with materials and processes, yet determination of the best materials and processes is part-and-parcel of every real engineering problem. Therefore, those aspects of materials and processes selection, which are either vital to the problem or interesting to the class member, are included wherever appropriate.

8. Solution

This is a thorough statement of the results, including an evaluation which compares the problem solution with its definition.

9. Follow-through

An industrial problem is never really solved. This section is anticlimatic in that it discusses "bugs" that develop later, customer complaints, design modifications, etc.

ASSIGNED PROBLEM

A weekly assigned problem challenges the class member to try his own skills along lines approximately parallel to those described by the product design study. The scope of the problem, by necessity, is less than that of the product design study; it is usually limited to a particular device or concept restricted enough to allow for a penetrative study, yet not so small as to be trivial.

Most of the assigned problems have already been solved by the operating department that has prepared it for the Course. However, several problems are real problems that have not as yet been solved.

The average length of an assigned problem statement is 10 pages, and includes about six photographs or drawings. Estimated time to read, understand, and work the problem is 10 - 14 hours.

Every assigned problem contains a carefully balanced mixture of the following ingredients:

1. Background material

The background material which is distributed supplements that of the product design study in the same package. In most cases, the product line described in both the product design study and the problem is the same.

2. Format

The problem presentation requires that the class member recognize and define the problem himself. All data necessary to the solution is included so that unnecessary assumptions need not be made.

3. Problem definition

If the class member defines the problem correctly, he finds himself confronting a situation very reminiscent of that confronted by the team of engineers in the product design study. However, this similarity is not stretched to the point where the two problems are identical.

4. Variety of reasonable solutions

Almost all the problems in the Course are of the multiple-answer variety. The competent class member is expected to recognize at least several possible solutions. Unlike academic problems, there is no one correct solution to a design problem. There could conceivably be as many good solutions to a problem as there are students.

5. Mathematical requirements

In the process of solving the problem, the class member is required to perform college-level mathematics.

6. Materials and processes

Selection of correct materials and processes is an inherent part of every design problem.

7. Physical configuration

The class member is required to sketch aspects of his solution to the assigned problem.

8. Cost consciousness

Every assigned problem includes some realistic aspect of cost determination.

Problem solutions are prepared in the format of a formal Company engineering report, complete with printed title page and cover.

SUPPLEMENTARY READING

Supplementary reading and reference materials in each week's package take the form of selected chapters from standard text and reference works, selected articles from technical magazines and journals, data folders from the G. E. Data Center, brochures from leading U. S. manufacturers, and advertising brochures from individual product departments which illustrate the product line being studied.

An average of 1 - 2 hours is required to read and understand this material.

THE WEEKLY CLASS

The weekly class is three hours long, and convenes during regular working hours in a classroom convenient to the Course members. The purpose of the class is threefold:

a. To discuss the assigned problem solved during the previous week.

b. To introduce the package which will be studied during the subsequent week.

c. To present lectures and conduct seminar-type discussions pertaining to the theoretical aspects of the week's Course material.

Class size is usually limited to about fifteen members. This limitation is necessary if individual counselling and guidance is to take place. Because the student derives great benefits from both rotating assignments and his course work on the product design studies and design problems, the Engineering Design Course is offered on a correspondence basis to students who have participated in a minimum of three months' classroom work and to men entering Military service.

CLASS SUPERVISORS

The full time class supervisors are graduates of the Company's technical programs and have considerable engineering experience and knowledge of the Company and its products. They spend a large amount of time counselling class members so as to relate their class performance and abilities to their future direction and to their training program assignments.

PLACEMENT

The Engineering Design Course is a terminal course; Engineering Program graduates usually choose to accept full-time engineering responsibilities in a product department as Advance, Design, or Production Engineers. There they may continue their education through Departmental Courses, Specialized Technical Courses, or Graduate Study under the Tuition Refund Plan.

ELIGIBILITY AND SELECTION

Eligibility for the Engineering Design Course is limited to college graduates who are members of any of the General Electric Company's several training programs. A college graduate who is not a member of one of the training programs may be accepted provided he has the approval of his supervisor.

Applications for the Engineering Design Course are made each summer, at which time applicants are asked to complete a required entrance design problem and mail the solution with the application form to the nearest Engineering Design Course class supervisor. The entrance problem serves two purposes: (1) it enables the prospective student to get an indication of the time required for study and the nature of the course material, and (2) it enables the Education and Training Section to evaluate the applicant's solution to help determine his compatibility with course objectives. Selection is made during July and August.

The Engineering Design Course is dynamic rather than "classic". As such, its text and problem material are undergoing a continual process of revision to keep them representative of the most modern technologies of the Company. The following subjects are typical of the class and homework effort:

1. Jet engine afterburner protective liner; problem: combustion system liner for a locomotive gas turbine.

2. The variable area supersonic nozzle; problem: strut design for the isentropic plug nozzle.



Class members take part in technical discussions with leading engineers from both inside and outside the company.

3. Value analysis techniques; problem: problems in value analysis.

4. Creativity and creative engineering techniques; problem: proposal for a new G. E. product.

5. The fogless bathroom mirror; problem: electron beam generator window cooling system.

6. Room air conditioner compressor-motor assembly; problem: room air conditioner permanent split-capacitor fan motor.

7. Ventilation requirements of housed capacitor equipments; problem: ventilation requirements of a new high-powered housed capacitor.

8. The four-poster control transformer; problem: further improvements in control transformers.

9. Clutch-brake loom motor; problem: (in three parts): basic ball bearing design, aircraft brake drum materials, appropriate size crane motor brake.

10. Portable food mixer; problem: portable food mixer four-way switch.

11. AGT compressor rotor blade pin joint fasteners; problem: pin joint fastener calculations.

12. Creativity and creative engineering techniques; problem: appraising and improving a creative engineering effort.

13. Household refrigerator magnetic closure; problem: part I - the GE rotating shelf household refrigerator; part II - ferro-magnetics; permanant magnet design procedures.

14. Hydraulic constant speed transmission for aircraft electrical systems; problem: the hydraulic constant speed drive governor.

15. Noise reduction in the "Thinline" room air conditioner; problem: part I - cool, ventilate, and exhaust features of the "Thinline" room air conditioner; part II - an engineering approach to noise evaluation.

16. Combination washer-dryer unbalance switch; problem: filter-flow washer basket balance ring fastener.

17. Electric skillet simmer control; problem: automatic drying cycle control system.

18. Creative Engineering Program Project: combination washer-dryer balancing project; problem: project problem - based on class members interests.

19. Patents and the production Design Engineer; industrial codes and standards; problem: project problem (concluded).

20. The all-new enclosed fuse cutout; problem: porcelain housing mounting for the enclosed fuse cutout.

21. Hermetically sealed transistor housings; problem: exercises in aspects of transistor design.

22. Appearance design and the product Design Engineer; problem: exercises in aspects of appearance design.

G - E HONORS PROGRAM FOR GRADUATE STUDY

The Honors Program for G-E provides the opportunity to continue your formal education with financial aid from General Electric, providing university and Company requirements are met.

OBJECTIVES

The rapid advance of application of technology in industrial problems has created a keen demand for men with advanced degrees. The Honors Program for Graduate Study was founded to provide engineers and scientists on the Engineering, Chemet, or Physics Program the first step in acquiring advanced knowledge in their chosen discipline. After earning a Master's Degree through the Honors Program, the Tuition Refund Policy, as administered by the operating components of the Company, offers the second step in study for their doctorate. Thus, the Honors Program is designed to give men who, have a sincere interest in pursuing graduate study leading towards a Master of Science degree the opportunity to attend a nearby university on a half-time basis.

CONTENT

Honors Program members participate in graduate study at Rensselaer Polytechnic Institute, Syracuse University, Case Institute of Technology, Cincinnati University, University of Pennsylvania, Cornell University, University of California at Berkeley and Harvard University. The choice of school will depend on the individual and the availability of challenging work assignments in his chosen field at a nearby General Electric Plant. Acceptance to the Program is conditional upon acceptance by the respective University.



Honors Program members, studying on a half-time basis, can receive their Master's Degree in a year and a half.

Honors Program members register for nine to ten credits a semester. Working hours are dovetailed around the academic program with the maximum work week set at 25-26 hours. Pay is based on hours worked, but full time employment during school vacations raises earnings to about 75% of full annual salary. When required, the thesis may be completed during the summer months, in the evening, or by using industrial work as a subject. The degree requirements may be completed in 3 or 4 semesters depending on the University attended.

At the end of the Program, members would be free to accept a permanent job anywhere in the General Electric Company. If they would like to continue their studies, they may do so in either our Advanced Engineering Program or our Creative Engineering Program. Some men, of course, will be interested in continuing their work toward a PhD, which will be handled through the Tuition Refund Program (described in back of booklet) of the department where they are permanently assigned.

ELIGIBILITY AND SELECTION

To be considered for this Program, one must have his BS or BA Degree from an accredited college, with better than B average, with his strongest grades in his major discipline and in mathematics. In addition he must have such a standing with his undergraduate faculty that they will recommend him for such a Program. In addition, you must meet the Company requirements by showing that this program best meets the needs of your program of self-development

Selection for this Program is on a continued basis. When one is convinced he wishes to apply, he should contact the office listed below immediately and action will be taken to consider his application. Graduate schools will accept men either up to capacity of facilities or registration time, whichever comes first.

If you are interested, contact immediately:

Honors Program for Graduate Study

Room 513, Building 36

Schenectady Works

ADVANCED ENGINEERING PROGRAM

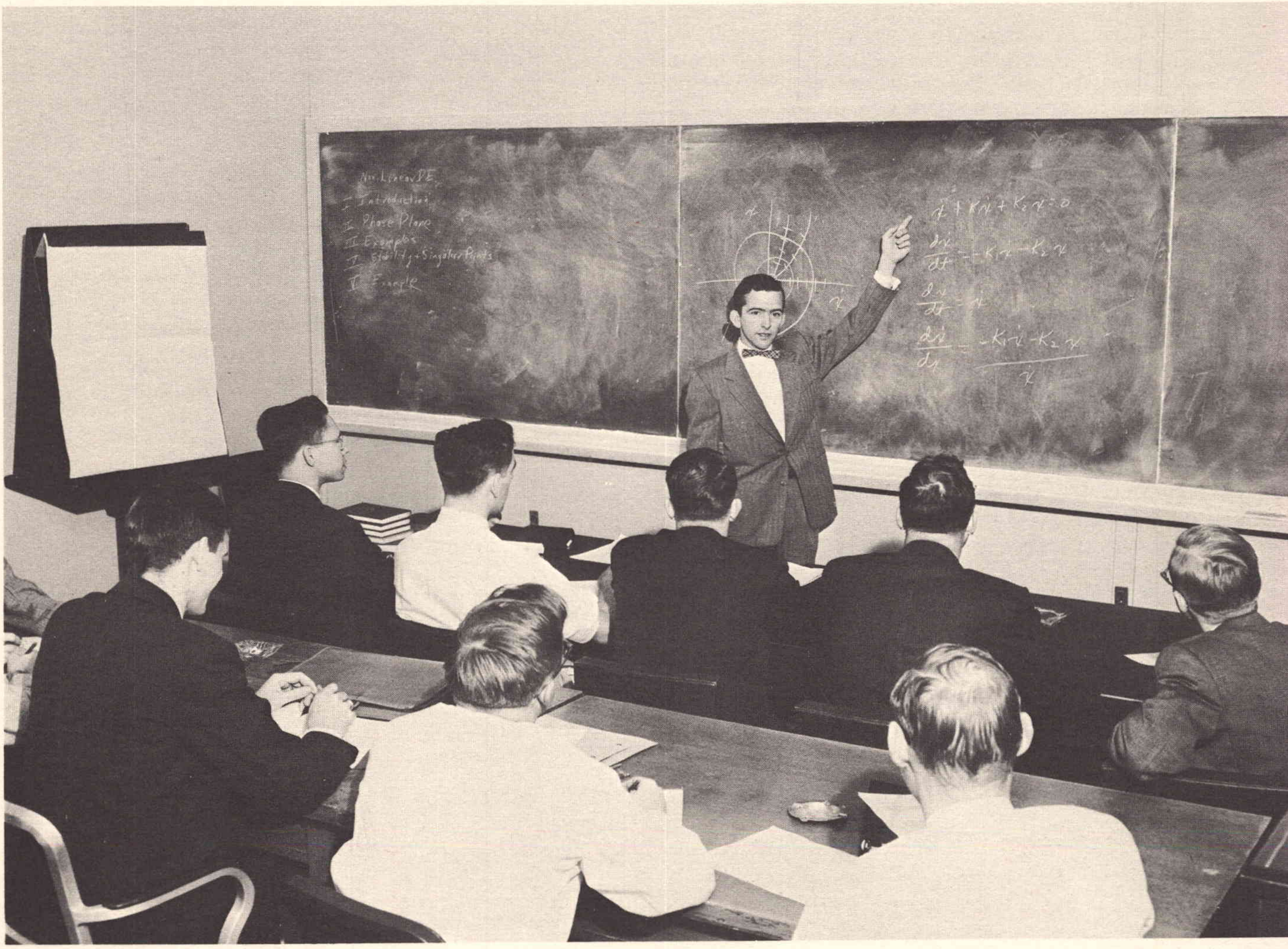
OBJECTIVES

The objective of the Advanced Engineering Program is to develop future engineering leaders for work areas where a deep and thorough understanding of physical principles is required.

The Program was founded over thirty years ago to satisfy the "demand for engineers who have more than ordinary knowledge of the principles of physics and mathematics, and the ability to apply them, and who are, therefore, competent to solve the engineering problems arising in the Company's business." This objective is still very valid today.

CONTENT

The Advanced Engineering Program develops this understanding and ability through an integrated 2-year program of formal classwork, homework, and engineering work assignments. During the "B" course and "C" course, the two respective years, he is on the program, an engineer will spend four hours in class each week taking part in technical discussions with leading engineers and scientists from both inside and outside the Company. This Program has the highest technical and mathematical content of any of General Electric's educational programs. The subject matter contained in the two



Lecturer discusses non-linear mechanics with B-Class of Advanced Engineering Program.

year program is outlined in detail under the individual courses.

The Program is extremely fortunate that the broad technical interests of the Company provide it with a great variety of challenging engineering problems. Furthermore Company engineers and scientists who are leaders in their fields are available for lectures and discussions on the many technical areas in the curriculum.

TEXT MATERIAL

When suitable textbooks are available to cover the technical material in one of the courses, they are issued to the class at Company expense. Where adequate text books have not yet been written, the classes are supplied with up-to-the-minute note material written by company experts.

HOMEWORK

Homework problems are assigned which require about twenty hours of outside effort per week. The homework problems are an extremely important part of the course activity, since a basic tenet of the Program is that one learns by doing. These problems, which are carefully selected to demonstrate fundamental principles, are typical of the most difficult technical problems being faced by industry. They are often of current interest in the operating departments, and each individual presents his solution in the form of an engineering report. (Refer to description of the B & C courses for sample problem.)

CLASS LOCATION

The location of Advanced Engineering Program classes is limited by the availability of suitable assignments. However, every effort is made to locate classes outside of Schenectady so that members can become familiar with work opportunities at other plants. During the 1956-57 year the classes were in the following locations: B-class, Lynn: B-class and Electronics C-Class, Syracuse; Fluid Mechanics C-Class, Evendale; and two B-Classes, Electromechanical C-Class and Systems C-Class all in Schenectady.

WORK ASSIGNMENTS

Except for four hours per week in class, the program member spends his working hours on a series of carefully selected assignments (usually three to six months in length) in the engineering sections of the Company's operating departments. Here he may work with an outstanding technical specialist or become part of a project team, but at any rate he will be working on difficult engineering problems, finding on-the-job applications for the technical material he learns in class.

PLACEMENT

Graduates of the Program generally take permanent assignments either in advance or development engineering, or in design engineering where there is a high technical content in the work. These men have made an excellent record as a group. The majority have either become engineering specialists or have taken on managerial responsibilities. There performance is excellent evidence of the effectiveness of the Program training.

ELIGIBILITY AND SELECTION

Because the Advanced Engineering Program involves a considerable investment of time by the individual and of time and expense by General Electric, candidates are carefully selected to assure that they are qualified for and will benefit from the Program. Since the B-Course curriculum presumes a broad and thorough acquaintance with engineering fundamentals, acceptance to the Program has the pre-requisite of completion of the Advanced Technical Course, the Honors Program, or the equivalent. Selections are usually made during the Spring of the year, but applicants will be considered during the Summer in special cases. Additional information regarding Program operation or selection may be obtained from the Advanced Technical Programs, Room 216, Building 31, Schenectady Works.

B-COURSE (FIRST YEAR)

This course extends the ability to recognize, define, and solve engineering problems by stressing physical application of advanced mathematical theory. Although the content is highly mathematical, the mathematics is presented only as a means of solving engineering problems, and it is so applied in the homework assignments.

Length of Course	-	34 Weeks
Class Time	-	4 Hours per Week
Outside Study	-	Approx. 20 Hours per Week
Prerequisities	-	Completion of the Advanced Technical Course, the Honors Program, or the equivalent.

Synopsis

Complex Variables

- Fundamental Concepts
- Complex Integration
- Conformal Mapping
- Joukowski
- Schwartz-Christoffel
- LaPlace Transforms
  (Ordinary D. E.)
  (Partial D. E.)
- Fourier Transforms
  (Ordinary D. E.)
  (Partial D. E.)
- Other X-Forms
- Feedback Control
- Root Locus

Applied To: Fluid Flow, E.M. Fields, Electronic Circuits, Heat Transfer

Matrices

- Fundamental Concepts
- Quadratic Forms
- Eigenvalues
- Matrix Iteration
- Kron's Method

Applied To: Network Analysis, Vibrations

Differential Equations

- Series Solutions
- Orthogonal Functions
- Adv. Concepts in Partial D. E.

Non-Linear D. E.
(Tropological Methods)
(Analytical Methods)

Applied To: Electronics, Dynamics, Stress Analysis, Heat Transfer, E.M. Fields

Integral Equations

- Introduction
  Green's Functions

Applied To: Dynamics, Heat Transfer

Calculus of Variations

- Hamilton's Principle
- Lagrange's Equations
- Ritz Method
- Semi-Direct Method

Applied To: Vibrations, Stress Analysis

Numerical Analysis

- Difference Equations
- Numerical Solution
  (Ordinary D. E.)
  (Partial D. E.)

Applied To: Heat Transfer, Stress Analysis

Computers

- Analogue
- Digital

Applied To: System Design, Fluid Flow

Nuclear Physics & Reactor Theory

- Production & Reaction of Neutrons
- Elementary Diffusion Theory
- Time Behavior
- Design Considerations

Probability & Statistics

- Probability
- Correlation
- Regression Theory

Effective Presentation

Sample of "B" Course Problem

TRANSIENT RESPONSE OF A FIELD WINDING

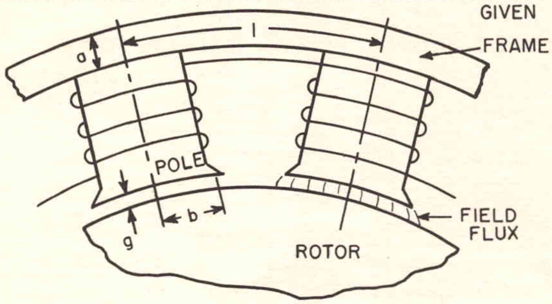
For steel rolling mills of the reversing type, large d.c. machines (on the order of 1000 kw each) are direct coupled to the rolls. Since high production of steel billets is synonomous with quick reversing, time constants must be minimized. However, instability must be avoided. Analysis of stability re-

quires knowledge of the transfer functions of the system. . When a large d.c. machine is considered as part of a control system, the field time constant often represents the largest single time lag in the system and so the transfer function between the applied vield voltage and resultant field flux is of primary importance.

The catch is that large d.c. machines are ordinarily constructed with solid frames. That is, the rotor and pole pieces are laminated but the frame (or yoke) is solid iron. Therefore, the changing field, current will be opposed not only by the magnetic circuit inductance, but also by the eddy currents developed in the solid iron frame. Therefore, the effects of these eddy currents must be considered.

In the evaluation of your results, how effective would a laminated frame be in reducing the time delay through the field circuit?

DIMENSIONS FOR A TYPICAL MACHINE ARE NORMALLY GIVEN



SOLUTION OUTLINE

To solve this problem, the electric circuit equations relating voltage, current and flux for the field, can be written. Ultimately, however, an expression involving only voltage and flux is desired. Hence, the magnetic circuit problem must be considered to relate flux to current. Since eddy currents can flow in portions of the structure, relating flux to current requires a solution of Maxwell's field equations, more specifically the diffusion equation. From the electric circuit and magnetic circuit equations, the desired transfer function can be written.

To find the time response of the flux for a step input of field voltage, Laplace transforms can be conveniently used. Evaluation of the inverse transform requires a contour integration in the complex plane.

By considering the portion of the time lag caused by eddy currents in the frame, the effectiveness of laminations can be determined.

ELECTROMECHANICAL C-COURSE (SECOND YEAR)

This course is designed to capitalize on a broad background in physical fundamentals and the advanced mathematical ability acquired in the B-Course to develop a deep understanding of the fundamentals and advanced analytical techniques in primarily mechanical areas. Since one primarily mechanical area is the broad field of electrical machinery, an Electrical Option is included in the curriculum to provide the man interested in this field with advanced electrical machinery topics.

Length of Course	- 35 Weeks
Class Time	- 4 Hours per Week
Outside Study	- 15-20 Hours per Week
Prerequisites	- Completion of B-Course or equivalent.

Synopsis

COMBINED SECTION (21 WEEKS)

Elasticity

Beams of Elastic Foundations

Theory of Plates & Shells

Thermal Stresses

Dynamics

Rigid Body Dynamics

Lumped Parameter Methods

Dynamics of Continuous Systems

Mobility Methods

Damped Systems

Vibration Measurements

Heat Transfer

Forced Laminar Convection

Forced Turbulent Convection

Free Convection

Acoustics

Classical Approach

Energy Methods

Electroacoustic Analogy

Physchological & Physiological Effects of Sound

Sound Measurements

Mathematics

Solution of Systems of Linear Equations

Diakoptics

Microscopic Behavior of Metals

Physics of Damping

Crystalline Structure of Metals

Human Relations

OPTIONS (14 WEEKS)

MECHANICAL

Elasticity

Variational & Energy Methods

Three Dimensional Elasticity

Method of Muskhelishvili

Elasticity Stability

Computer Methods

Photoelasticity & Other Experimental Methods

Classical Plasticity

General Theory in Tensor Notation

Plain Strain

Yield Criteria

Limit Design

Other Non-Linear Behavior of Metals

Anelasticity

Creep

Fatigue

Fracture

Microscopic Behavior of Metals

Plastic Behavior of Crystals

Influence of Microstructure on Fracture

ELECTRICAL

Machine Theory

Two-Axis Theory

Symmetrical Components

Machine Transients

Reactance Theory

Physics of Materials

Atomic Structure

Band Theory & Introduction to Quantum Theory

Magnetism & Magnetic Amplifier Theory

Dielectrics

ELECTRONICS C-COURSE (SECOND YEAR)

This course is designed to capitalize on a broad background in physical fundamentals and the advanced mathematical ability acquired in the B-Course to develop a deep understanding of the fundamentals and advanced analytical techniques in the area of electronics.

Length of Course	- 35 Hours
Class Time	- 4 Hours per Week
Outside Study	- 15-20 Hours per Week
Prerequisities	- Completion of B-Course or equivalent.

Synopsis

Network Analysis and Synthesis

Input Impedance Synthesis

Filter and Transfer Function Synthesis

Potential Analog and Insertion-Loss Theory of Filter Design

Non-Reciprocal Networks

Bode Integral Theorems

Sampling and Numerical Transient Analysis

Fields and Radiation

Applications of Maxwell's Equations

Transform Solution of Boundary-value Problems

Transmission Lines, Wave Guides and Cavities

Fundamentals of Radiation

Antenna Diffraction Theory

Microwave Tubes

Semiconductors

Atomic Physics

Quantum Mechanics

Semiconductor Physics

Transistor Equivalent Circuits

Magnetic and Dielectric Devices

Communication Theory

Correlation Theory and Power Spectra

Generalizied Harmonic Analysis and Optimum Filters

Properties of Noise and Amplifier Noise

Information Theory for Discrete and Continuous Codes

Human Relations

FLUID MECHANICS C-COURSE (SECOND YEAR)

This course is designed to capitalize on a broad background in physical fundamentals and the advanced mathematical ability acquired in the B-Course to develop a deep understanding of the fundamentals and advanced analytical techniques in the area of Fluid Mechanics.

Length of Course	-	34 Weeks
Class Time	-	4 Hours per Week
Outside Study	-	15-20 Hours per Week
Prerequisites	-	Completion of B-Course, or equivalent

Synopsis

Incompressible, Non-viscous Flow

Potential Theory

Vortex Theory

Free Streamline Theory

Flow through Turbomachinery

Picture Plane Methods

Hodograph Synthesis Methods

Compressible, Non-viscous Flow

Linearized Theory

Characteristics Methods

Slender Body Theory

Conical Flow

Transonic Flow

Hodograph Methods

Boundary Layer & Heat Transfer

Incompressible Laminar Boundary Layer

Instability, Transition, Turbulence

Compressible Boundary Layer

Laminar Heat Transfer

Turbulent Heat Transfer

Jets & Wake Flow

Transient & Unsteady Flow

Acoustics

One-Dimensional Charactersitics

Interaction of Traveling Waves

Shock Tubes

Aeroelasticity

Statistical Mechanics

Kinetic Theory

Thermodynamics

Bearing & Lubrication Problems

Human Relations

SYSTEMS C-COURSE (SECOND YEAR)

This course is designed to capitalize on a broad background in physical fundamentals and the advanced mathematical ability acquired in the B-Course to develop a deep understanding of the fundamentals and advanced analytical techniques in the area of systems design and analysis.

Length of Course	-	35 Weeks
Class Time	-	4 Hours per Week
Outside Study	-	15-20 Hours per Week
Prerequisities	-	Completion of B-Course or equivalent.

Synopsis

Mathematics

Integral Transforms

Convolution

Duhamels Theorem

Hilbert Transform

Bode Integral Theorems

Physical Realizability of Systems

Linear Systems

Linear Systems Analysis

Introduction to Industrial Systems

Time Response Techniques

Root Locus

Multiple Input Systems

Power Systems

Krons Method

System Stability

Network Synthesis

Driving Point - Realizability Critieria

Transfer Function Impedances - Synthesis Procedures

Approximation Methods - Conformal Transformations

Active Network Synthesis

Statistical Communication & Information Theory

General Harmonic Analysis

Weiner Optimum Filters

Information Theory

Sampling Theory & Characteristic Noise Study

Non-Linear Systems

Non-Linear Mechanics

Describing Functions

Sampling Servos

Periodic Controllers

Small Perturbation Theory

Components

Magnetic Devices - Amplifier, Saturable Reactors, Amplidynes

Transistors

Nuclear Reactor Theory

Electrical Machine Theory - Primitive Machine Concepts

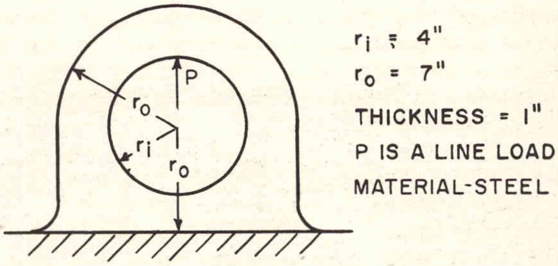
Hydraulic Components

Gyrodynamics

Concepts of Systems & Projects

Sample "C" Course Problem
Lifting Lug Stresses

Heavy pieces of equipment are usually fitted with lifting lugs for crane movement during assembly and installation. A typical lug is sketched below.



You are asked to evaluate the stresses in any critical areas of the plate.

SOLUTION OUTLINE

A first approximation may be obtained by ignoring the outer boundary of the lug and treating it as an infinite plate. The problem may then be solved by superimposing a set of airy stress functions to match the load and free edge boundary conditions, and evaluating the stresses and displacements from these stress functions. The functions must be selected so as to yield single-valued displacements.

The solution obtained in this manner may be improved by using minimum free energy principles or other, approximate numerical methods to eliminate the stresses at the outer boundary.

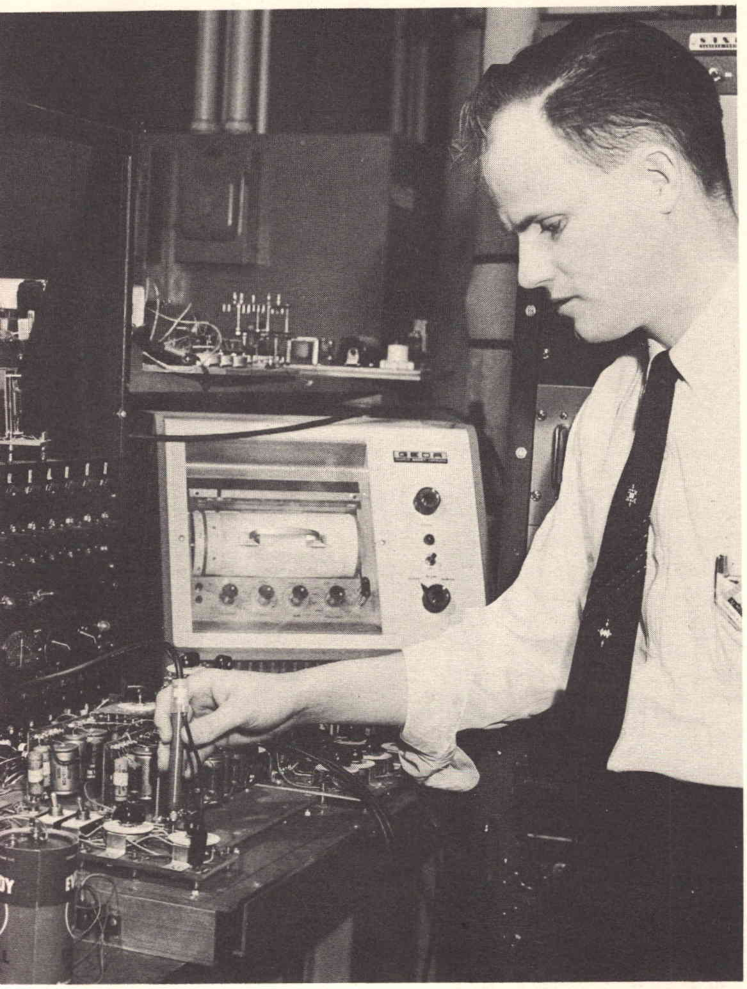
In order to arrive at an accurate analytical solution to this problem, a thorough understanding of basic elasticity, airy stress functions, partial differential equations, and minimum energy principles is desirable.

CREATIVE ENGINEERING PROGRAM

OBJECTIVES

The objective of the Creative Engineering Program is to increase the engineer's ability to conceive ideas, to strengthen in him the technical knowledge necessary to evaluate his ideas, and to give him confidence in the application of his ideas to the solution of engineering problems. It emphasizes the development of deliberate inventiveness and the perspective necessary to attain product leadership.

Today's rapidly expanding technology and the steady stream of new and improved products mean that General Electric needs ever increasing amounts of creative and imaginative thinking in its engineering work. In the Creative Engineering Program the engineer will learn to maintain an open mind, to acquire constructive discontent, to look at problems from an objective point of view, and to rapidly arrive at unique problem solutions.



Creative Engineering Program man on assignment in the General Engineering Laboratory conducts experiment on a control system.

CONTENT

The topics covered in this course are designed to increase the engineer's ability to gain ideas, to evaluate them on the basis of sound thinking, to utilize them fully, and utlimately to get acceptance for them.

The program accomplishes this through an integrated schedule of classwork, homework, and engineering work assignments. During the year he is on the Program, an engineer will spend four hours in class each week during working hours discussing technical subjects and creative techniques with the Company's leading inventors and creative engineers.

Length of Course	-	34 Weeks
Class Time	-	4 Hours per Week
Outside Effort	-	20 Hours per Week
Prerequisities	-	Graduation from the Advanced Technical Course, an M.S. degree, or the equivalent.

Synopsis

The Conception of New Ideas

I Problem Solving Procedure
1. Recognition
2. Definition
3. Search
4. Origination
5. Evaluation
6. Selection
7. Optimization & Execution
8. Presentation

II Creative Techniques
1. New and Unusual Devices
2. Modification Techniques
3. Laws and Effects
4. Imagination Stimulators
5. The Phases of Synthesis
6. Group Techniques
7. Idea Notebooks
8. Morphological Analysis
9. Gordon Technique
10. Operational Methods
11. Attribute Analysis

III Creative Application
1. Individual Development Project
2. Group Development Project
3. Science Fiction Article
4. Departmental Design Problems

Demonstration of Idea Feasibility

I Technical Evaluation
1. New Physical Fundamentals
2. Fundamentals of Basic Materials
3. Atomic Physics
4. Study of Electromagnetic Spectrum

5. Empirical Analysis
6. Statistical Analysis

II Engineering Functions and Relationships

1. Development
2. Design
3. Manufacturing
4. Value Analysis
5. Legal and Patent
6. Purchasing
7. Marketing

III Related Knowledge

1. Group Product Design
2. Presentation of Projects to Engineering Managers
3. Project Consultations with Experts
4. Engineering Tours

Group development projects are another phase of Program Training. Here again, the problems are actually submitted by the operating departments. After screening, these problems are selected by members of the class and the class broken into groups depending on their interests. These groups then attack the problem from a creative point of view, creative solutions are decided upon, and actual working models are built in the well-equipped and complete Creative Engineering Program workshop.

The final phase of the Creative Engineering Program is the reduction of the development idea to a practical manufacturing product. In all engineering work, it is exceedingly important that the solution be capable of practical application, be within the realm of production feasibility, and be within the cost and performance requirements dictated by our economy.

The results of the group project, which in most cases will be a prototype model, are analyzed from a manufacturing viewpoint by the groups. By actually specifying the product for manufacture in this manner, the class members gain an understanding of cost and performance requirements on a practical basis.

TEXT MATERIAL

Extensive and unique material has been prepared by the Program staff, with the help of Company experts, and this is distributed to the class members.

HOMEWORK

Homework is assigned which requires about twenty hours of outside effort each week. This homework is carefully designed to stimulate the imagination and to develop the engineer's ability and confidence in creative problem solving. In most cases, the individual works on problems submitted to the Program by the Company's engineering sections. The solutions of the class members are then discussed by the engineers who submitted the problem. Homework assignments require approximately twenty hours of preparation per week.

SAMPLE PROJECT PROBLEM

The following description of a development and design project illustrates the type of project problems undertaken in the Creative Engineering Program:-

All electric motors today depend on electromagnetic forces for operation whereas, surprisingly, none utilize electrostatic phenomenon. The reason for this is apparently due to the theoretically superior power storage capability of a magnetic field compared to an electrostatic field. Recognizing this failure of industry to exploit electrostatic applications, and the fact that some applications do not require much power (electric clocks or timers), the development of an electrostatic motor was undertaken by a CEP project group.

Initially, electrostatic phenomena were investigated to obtain a firm understanding of the theoretical aspects of electrostatics, including force and field considerations. Having acquired a general background, a number of possible electrostatic motor schemes were conceived and a prototype model of one of these schemes was constructed in the CEP model shop. This model, consisting of a number of pie-shaped segments forming a rotor revolving between stators of a similar segmented construction failed to generate sufficient rotating torque, and this method was discarded as unfeasible.

A second, entirely different scheme was then selected for development.

This method utilized the precession which occurs when a very shallow cone rolls on a plain surface. The shallow cone comprised the rotor of the motor and electrostatic forces occur between the cone and the plane causing elements of the cone to be attracted to the plane and creating a subsequent rotation of the cone. A feasibility proving model was constructed with external synchronization and the model performance was successful. Speeds of 180 rpm were obtained.

A thorough understanding of electrostatic fields and vector analysis was required to adequately predict the model performance prior to model construction. Analyses were made of viscous drag forces. bearing torques, integrated force distributions and dielectric stresses. Fundamentals learned in the Advanced Technical Course and in subsequent study by the group were of extreme importance in the model analysis.

Curves were drawn from data obtained on torque and speed characteristics of this device and the development of the operating principle was considered complete.

The final phase of the project consisted of the practical application of the principle which had proven to be feasible. The application selected was an electrostatic clock motor designed to be self starting, synchronized, and unidirectional. The completed view of the final design is shown in Figure 1, and is intended to capitalize on the ''Mystery Clock'' feature so easily obtained with this operating principle. The clock is transparent, being constructed in large part of clear plastic, with electrical connections and surfaces being made of transparent conductive coatings formed by electric deposition processes developed in the General Engineering Laboratory. Parts are shown in Figure 2.

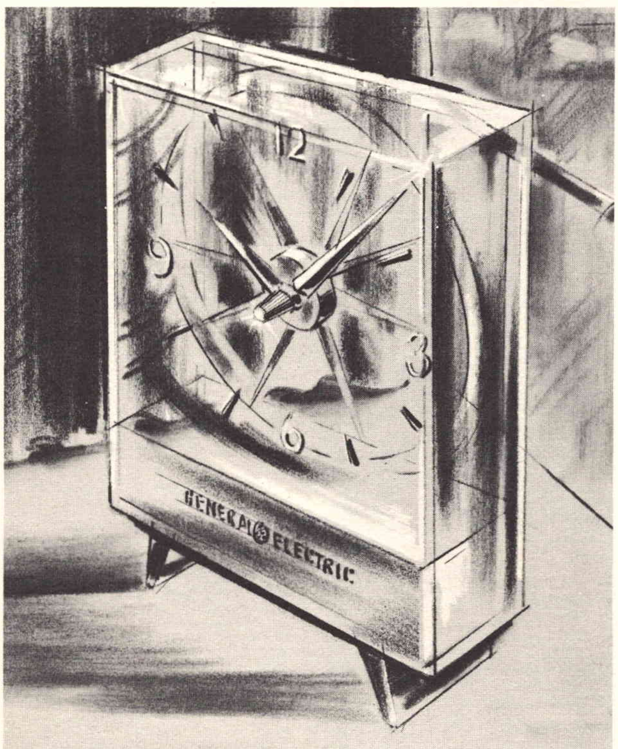


Figure 1

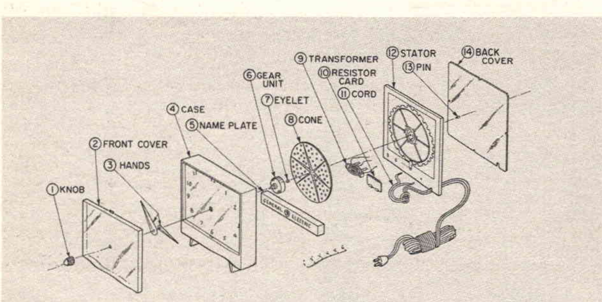


Figure 2

The essential rotating component consists of a shallow, transparent cone which rolls around on a conductive pattern printed on the flat plate stator. Its synchronous rotating speed is 1/5 RPM, surprisingly low compared to electromagnetic motor speeds of 3600 RPM. For the projected design, a process flow chart, a manufacturing layout, and sketches were made of every element of the assembly. Cost estimates were then compiled with the aid of company and vendor quotations. The shop cost (the sum of material, labor and indirect manufacturing expense) resulted in an accurate estimate of cost as sold to the retailer.

The features of this motor are now being considered for possible product application in the Telechron Clock Department.

WORK ASSIGNMENTS

Program members spend their working hours on a series of carefully selected assignments, usually three months in length. Here the individual will have an opportunity to work with outstanding inventors and creative contributors, and to acquire additional insight and practice in creative problem solving. He will also learn about the many functions, such as manufacturing and marketing, that contribute to a product, and the importance of the engineer in the overall picture.

PLACEMENT

There is a tremendous need in industry for engineers with the creative ability to think up new and imaginative solutions to engineering problems, and with the technical ability to evaluate their solutions and carry them to completion in a product. Creative Engineering Program graduates have done well in satisfying this need and have established excellent records in the company's engineering sections.
They have found success in a wide diversity of departments and fields. The jobs are usually in areas where futuristic, but yet realistic, thinking is of paramount importance.

ELIGIBILITY AND SELECTION

Because the Creative Engineering Program involves a considerable investment of time by the individual and of time and expense by General Electric, candidates are carefully selected to assure that they are qualified for and will benefit from the Program. Since the Creative Engineering Program curriculum presumes a broad and thorough acquaintance with engineering fundamentals, acceptance to the program has the prerequisite of completion of the Advanced Technical Course, an Engineering M.S. degree or the equivalent. Selections are usually made during the Spring of the year, but applicants will be considered during the Summer in special cases. Additional information regarding Program operation or selection may be obtained from the Advanced Technical Programs, Room 216, Building 31, Schenectady Works.

ADVANCED SCIENCE PROGRAM

Advanced training for graduates with Bachelors' degrees in chemistry, metallurgy or physics can be obtained through the Advanced Science Program. Similar to the Honors Program but with a somewhat slower educational pace, the Advanced Science Program leads to a Master of Science degree in in approximately two years.

OBJECTIVES

The intent of this Program is to provide advanced training for men who are interested in work of a basically scientific nature.

CONTENT

Men on the Advanced Science Program spend thirty-six hours per week on engineering assignments which are nominally three months long. The remaining four hours of the normal work week are spent in graduate study at a university. In addition, some evening classes are taken. These men receive full pay from General Electric. Also, the Company pays all expenses for tuition, fees and books.

Under this Program, a man can carry approximately six credits of graduate work per semester. This allows completion of the Course work requirements for a Master's degree in four semesters. Thesis work may be done at General Electric if a work assignment can be found which provides a suitable thesis topic. This must be approved by the thesis adviser. If such an assignment cannot be found, thesis work may be done in the summer between the two academic years.

CLASS LOCATION

All members of the Advanced Science Program are presently located in Schenectady. This area provides a wealth of assignments of a scientific nature due to the presence of the Research Laboratory, Knolls Atomic Power Laboratory and the General Engineering Laboratory. Program members attend class at nearby Renssalear Polytechnic Institute in Troy, New York. The program will be expanded to the following areas and schools for the 1957-58 school year: Evandale - University of Cincinnati; Syracuse - Syracuse University; Cleveland - Case Institute.

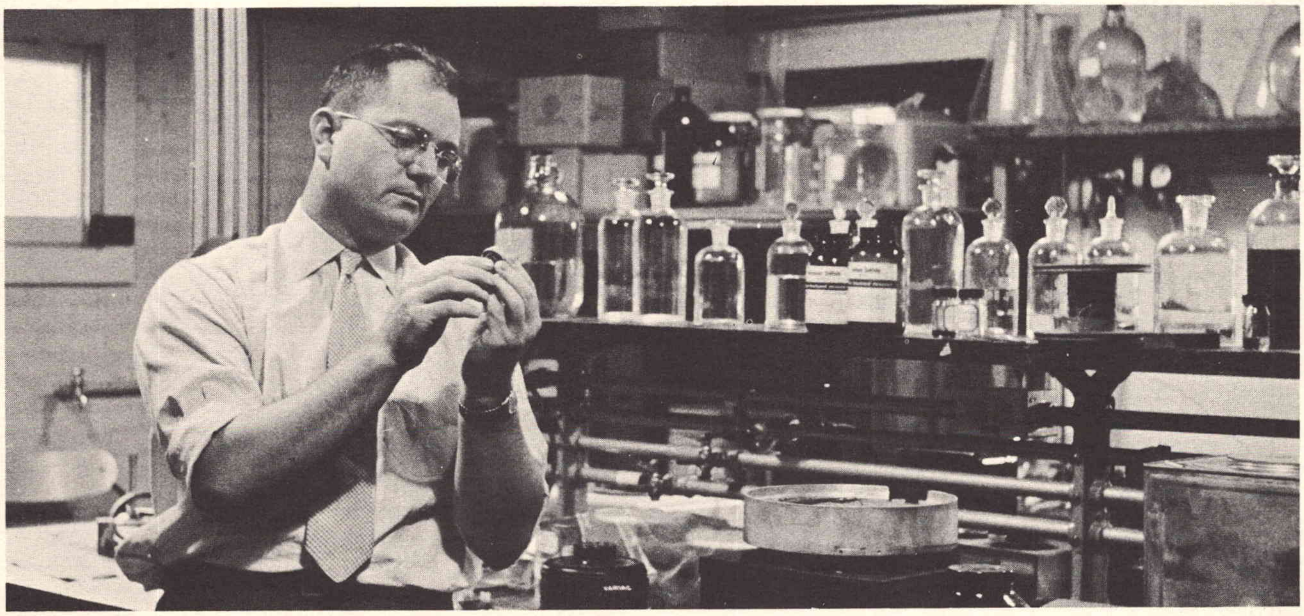
PLACEMENT

Graduates of the Advanced Science Program are normally placed in one of the laboratories or advance engineering sections of the Company. Those interested in continuing for doctorates will have the opportunity to do so after placement, through the regular tuition refund policy.

ELIGIBILITY AND SELECTION

Men are selected for the Advanced Science Program on the basis of their interest and their ability to do high level work. All members must, of course, be found acceptable for graduate study by the participating schools.

All graduates in chemistry, metallurgy or physics are eligible for this Program after the successful completion of the Advanced Science Course.



Class members spend thirty-six hours a week on regular engineering assignments and four hours a week studying for their Master's Degree.

SPECIALIZED TECHNICAL COURSES

OBJECTIVES

The engineering skills of operating departments are one of the main stays of General Electric Company's success and reputation. In order to maintain this engineering leadership, Specialized Technical Courses are offered to help department engineers and associated personnel meet future technical opportunities.

Engineering Managers continue to increase the efficiency of their people by determining what technical knowledge will be needed in the future, by selecting those who will profit from this additional study, and making these courses available. Those who do continue their education can increase their potential and thus prepare themselves for those future technical opportunities.

SUMMARY OF SPECIALIZED TECHNICAL COURSES

NAME OF COURSE	WEEKS DURATION	CLASS HOURS PER WEEK	ESTIMATED HOURS OF STUDY PER WEEK
Electronic Computations	14	2	8-10
Principles of Stored Program Computers	14	3	8-10
Numerical Methods and Mathematical Analysis	13	3	8-10
Statistical Analysis	27	3	8-10
Creative Approach Seminar	16	2	8-10
Principles of Servomechanisms	26	3	6-8
Automatic Control Systems	26	3	8-10
Engineering Analysis I and II	60 (over 2 yr. period)	3-4	10-12
Vibrations	16	2	6-8
Heat Transfer	26	3	4-6
Advanced Heat Transfer	36	3	8-10
Fluid Dynamics	18	2	8-10
Electronics Circuits	13	2	6-8
Principles and Applications of Transistors	26	2	8-10
Electromagnetic Fields	24	2	6-8
Magnetic Materials and Applications	19	2	6-8
High Polymer Materials	13	2	4
Plastics Engineering	13	2	2-3
Insulation Seminar	Presented as 5 all-day sessions		
Engineering Design	26	2	12

COURSES FOR PARTICULAR NEEDS

Specialized Technical Courses provide the engineer with an opportunity for further education in the specific fields of his interest.

These courses cover a wide variety of engineering and scientific subjects as dictated by the educational needs of the operating departments. Although they are fundamental in nature, they are also specific enough to produce immediate practical benefits.

The courses have been developed by authorities in the various fields. They are tested throughout the company, evaluated for their success, and revised as warranted. The courses are taught by qualified instructors who have had professional experience in their respective subjects. As preparation for their teaching duties, these instructors are encouraged to attend a one-week summer seminar where teaching techniques and course material are presented and discussed.

By the use of this method of course development and presentation, the latest technological advances are more effectively absorbed by the engineer.

DEPARTMENTAL COURSES

Quite often an engineer needs training in a specific subject that is not available from outside sources. In this event, the department involved establishes a course to provide the necessary information and training. In most departments in General Electric there are courses that are tailored to fit the specific needs of that department. Examples of this type of course are the Transformer Design Courses in the Transformer Department, Advanced Servo Course in the Aeronautics and Ordnance Systems Divisions, and the Nuclear Physics Course in the Knolls Atomic Power Laboratory.

TYPICAL DEPARTMENTAL COURSE IN "GAS TURBINE FUNDAMENTALS"

Objectives

To provide an orientation to the highly technical theory behind the functioning of Aircraft Gas Turbines. Thermodynamic and Aerodynamic aspects of Gas Turbine design and performance are stressed.

Content

Thermodynamics (a quick review), Brayton and other cycles; Principles of Propulsion; Elementary Cycle Analysis; Elementary Mission Analysis; Dynamic Similarity; Gas Dynamics; Flow in Ducts; Nozzles and Diffusers, review and examination. Transfer of Energy; Radial Equilibrium and Continuity; Compressor Design and Performance; Turbine Design and Performance; Controls and Mechanical Design; Engine Performance; Other Power Plants; Airplane Aerodynamics and Performance.

Homework

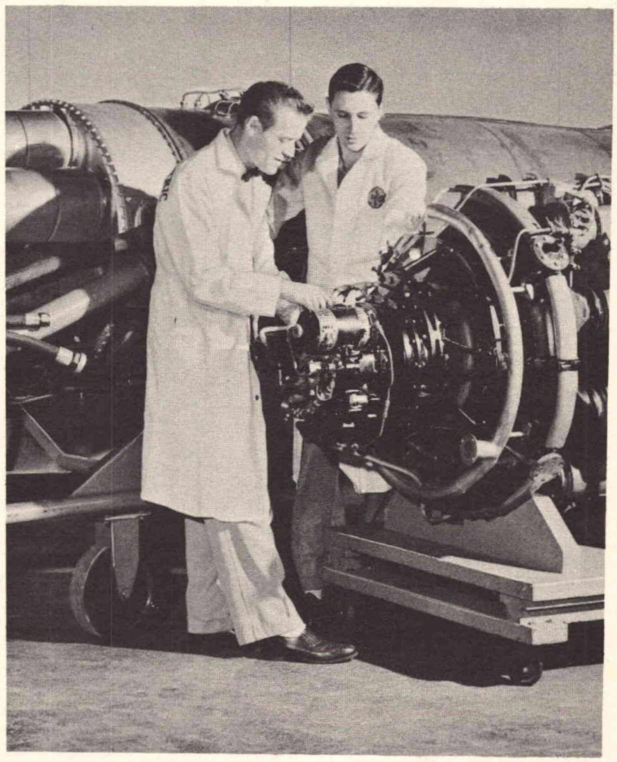
Approximately 8-10 hours of personal time will be required to prepare each assignment. The course lasts for 34 weeks, each class a two-hour session during normal working hours.

Instructors

The two present instructors are J.R. Geyer, Supervisor, J47-73 Air Design, Jet Engine Dept. and I.W. Victor, Technical Engineer, Advanced Engineering, Engineering Section, Jet Engine Dept.

Eligibility and Selection

Engineers who have not, through educational background or experience acquired an understanding of the application of fundamental thermodynamics to Aircraft Gas Turbines are preferred. Eligibility for this course is based upon the individual possessing a fair understanding of thermodynamics. Admittance to the course will be determined by the individual class instructor who shall personally interview all applicants.



Departmental courses provide training and education in specific subjects that are not covered by the other phases of the Advanced-Study Program.

TUITION REFUND PROGRAM

Under this Program you may take individual graduate courses at Company expense at leading schools and universities in your vicinity.

OBJECTIVES

In view of the constant increase and complexity of the Company's products and the techniques of their production, together with the need to meet this complexity through the use of advanced technology, the Tuition Refund Program is designed to permit the individual departments of the Company, at their option, the opportunity to provide their engineers with educational aid and training opportunities in specific related subjects for advanced degrees related to the engineer's field of work.

The primary purpose of the Tuition Refund Program is to encourage an engineer to voluntarily fill in specific voids or to strengthen specific weaknesses in his education background in his field of work so that his contribution to his assignment is improved and his progress in that component and in the Company is enhanced.

Where approval has been given in advance under this Program for an engineer to undertake the work leading to an advanced degree in the field of his work and he has been accepted by the recognized college or university as a candidate for that degree, all the courses required for the completion of that degree may be considered as subject to reimbursement.

BASIC TUITION REFUND PROGRAM

A Department General Manager may grant tuition refunds up to 100% of the amount of tuition paid by an engineer who, with prior approval, voluntarily enrolls in and successfully completes a course or combination of courses leading to a degree at a recognized school, college, or university, provided such courses relate to the field of the engineer's work with the Company.

MODIFICATIONS

a. A Department General Manager, in addition to authorizing a tuition refund, may permit an employee to be absent from work part time for the purpose of participating in an educational course. Normally, these absences should not amount to more than four hours per week and in addition, such absences will normally only be approved when the required course or courses of study are unavailable at a time outside the engineer's normal working schedule. During such approved absences, the engineer would receive no reduction in pay.

b. Leave of absence for educational reasons: A Department General Manager may recommend that a leave of absence be granted to an outstanding engineer who has proven his worth to his department by his performance for a period of at least two years. The leave must be for the purposes of completing the requirements leading to an advanced degree in the field of the engineer's work. The leave of absence would include only the actual time needed to complete the necessary degree requirements and it is intended that the engineer return to the Company promptly upon the completion of the course of study. The amount of the leave allowance is at the discretion of the department General Manager but he will normally be guided by the current awards being given for graduate fellowships. If practical, the Department General Manager may provide employment during any extended recesses during the engineer's course of study.

c. Related educational programs: A Department General Manager may establish a local part-time training program in conjunction with a college or university in his vicinity to provide specific educational opportunities for his employees.

APPROVAL

All individual educational programs must have prior approval of the department's management in order that it may come under the Tuition Refund Program. Also, the course of study must be taken at a recognized school, college, or university and the course must be completed successfully.

It should be pointed out that enrollment by the engineer in the school, college, or university is on a voluntary basis. The present tax laws have ruled that the Tuition Refund is taxable as ordinary income and is subject to withholding tax and Social Security.

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